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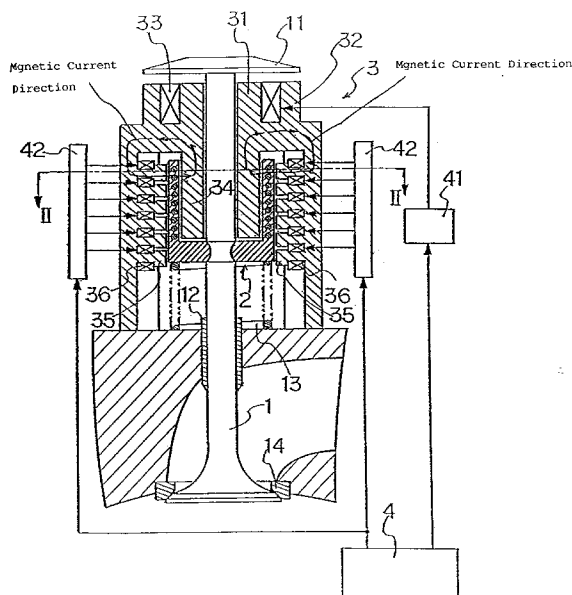
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(54) **Electromagnetic valve actuating system.**

(57) An apparatus for driving valve by electromagnetic force, for an engine capable of being installed in a narrower space due to the interfering object or narrow arrangement pitch of a supply / exhaust valve, comprises : a fixed magnetic pole 35 which is wound with the primary coils 36 and which is opposingly disposed embracing the secondary coils 22 in the perpendicular direction to the reciprocating direction of the secondary coils ; an air gap adjacent with a tip end of the fixed magnetic pole and provided in the middle of a magnetic flux path generated from the primary coil ; a movable element 2 adapted to be made of magnetic substance, to move freely reciprocating in the air gap, to form part of the magnetic flux path, and to contain the secondary coils.

Fig. 1



BACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

The present invention relates to an electromagnetic force valve driving apparatus for capable of driving opening and closing a supply / exhaust valve of an engine by an electromagnetic force.

(DESCRIPTION OF THE PRIOR ART)

In opening / closing drive apparatuses of the conventional supply / exhaust valves, the supply / exhaust valves adapted to always be biased in closing direction by spring are driven of their opening and closing by depressing each shaft end face of the valves through a link mechanism such as a locker arm, a pushing rod and the like from a cam surface of a cam shaft which is driven by an output shaft of an engine and is rotating synchronously in phase with rotation of the engine.

An engine configuration of the opening / closing drive apparatus requires as described above a larger size engine due to provision of the cam shaft and link mechanism within the engine. Also friction resistance on driving the cam shaft and link mechanism causes provides partial dissipation of engine output, lowering effective engine-output.

Since the open / close timing of the supply / exhaust valve is impossible to vary easily during operation of the engine, the open / close timing of valve must be adjusted to optimize its running condition at a specific rotation speed of the engine. Accordingly when running at a rotation speed differing from the specified one, it is impossible to obtain satisfactory output and efficiency which the engine intrinsically exhibits.

To solve the problem as hereinbefore described, unlike the open / close drive of the supply / exhaust valve by cam shaft, various kinds of valve drive apparatuses are disclosed in the Japanese Patent Application Laid Opens No.183805 in 1983 and No.76713 in 1986, such that the valve drive apparatuses are adapted to open and close the supply / exhaust valve capable of varying the opening / closing timing thereof by means of attracting movable magnetic poles connected to the supply / exhaust valve using an electromagnetic force of magnet fixed on the engine.

(Subject to be Solved by the Invention)

When the engines are actually applied with the conventional valve drive apparatuses adapted to drive opening / closing of the supply / exhaust valve by electromagnetic force as hereinbefore described, then a construction capable of generating a very strong magnetic force is required for reliably driving

the supply / exhaust valve and for enabling to operate in a region of high speed rotation.

A requirement of generating very strong magnetic force results in enlarging a magnetic flux density and thus expanding a cross section of magnetic path.

The expanded cross sections of magnetic path, or enlarge the drive apparatuses, creates a problem that because an interference arises by the adjacent drive apparatuses of the supply / exhaust valves being overlapped, these adjacent drive apparatuses can not be accommodated in an engine.

The problems as hereinbefore described are not solved in the Japanese Patent Application Laid opens as in the foregoing because they do not disclose teach arrangements in employing a narrower pitch for installation of the supply / exhaust valve or in assembling the drive apparatus in a narrow space.

The present invention is made in the light of the problems described above, and an object of the invention is to provide an apparatus for electromagnetic force valve driving apparatus capable of generating very strong electromagnetic force even when in a narrow pitch for installation of the supply / exhaust valve and in assembling within a narrow space due to a barrier or an interfering object.

(SUMMARY OF THE INVENTION)

An apparatus for driving an electromagnetic force valve in accordance with the present invention drives a supply / exhaust valve by an electromagnetic force acting between primary coil and secondary coils, the primary coil being fixed on an engine and generating magnetic flux, the secondary coils capable of reciprocating movement being connected to the supply / exhaust valve and capable of inducing current by the flux, the invention is to provide an electromagnetic force valve driving apparatus characterized by comprising: a fixed magnetic pole which is wound with the primary coils and opposingly disposed embracing the secondary coils in the perpendicular direction to the reciprocating movement direction of the secondary coils; an air gap adjacent with a tip end of the fixed magnetic pole and provided on any position of a magnetic flux path generated from the primary coil; a movable element made of magnetic substance, and movable reciprocatingly in the air gap, to form part of the magnetic flux path, and to contain the secondary coils. Thus an object of the present invention is achieved.

An electromagnetic force valve driving apparatus provided with the constitution as hereinbefore described, since a fixed magnetic pole is provided opposingly embracing the primary coil, width of the perpendicular direction to the opposing direction of the fixed magnetic pole is reduced to enable installation in a narrower space and a very strong electromagnetic force is allowed to exert on the movable

element in good balance. In this way, the present invention can provide an apparatus for driving valve by electromagnetic force capable of generating a very strong electromagnetic force even in the arrangement of the supply/ exhaust valve with narrower installation pitch or in assembling in a very narrow space due to an interfering object because the width of the perpendicular direction to the opposing direction of the fixed magnetic pole is reduced to enable installation in the narrower space. And allowing a very strong electromagnetic force to be exerted on the movable element in good balance since the fixed magnetic pole is oppositely arranged embracing the primary coil.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram showing the constitution of an electromagnetic force valve driving apparatus according to the present invention.

Figure 2 is a sectional view taken along line II-II in figure 1.

Figure 3 is a sectional perspective view of a moving element of an electromagnetic force valve driving apparatus

Figure 4 is illustration showing magnetic flux exerting on a movable magnetic pole of an apparatus for driving an electromagnetic force valve driving apparatus according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described in detail for embodiments with reference to the accompanying drawings as follows.

Figure 1 is a block diagram showing constitution of an apparatus for driving valve by electromagnetic force according to the invention. Figure 2 is a sectional view taken along line II-II in figure 1. A supply valve and an exhaust valve are provided in an engine as hereinbefore described. However since the driving apparatus in accordance with the present invention can be applied to both of the supply valve and the exhaust valves, then hereinafter the apparatus for opening and closing the supply valve will be essentially described.

Numeral 1 is a supply valve made of ceramic material such as silicon nitride etc which is light in weight and excellent in strength in higher temperature. A movable magnetic pole 11 of disk shape is connected to a shaft end of the supply valve 1. The movable magnetic pole 11 is formed to be thinner in thickness as the distance from its center toward peripheral portions increases. The area of magnetic path formed between the movable magnetic pole 11 and a fixed magnetic pole described later is set uniform from the center to the peripheral portions.

The supply valve 1 is pivotally supported capable

of freely reciprocating by a valve guide 12, and during the closing of the supply valve 1 an umbrella-shape portion of the supply valve 1 sits on a valve seat 14 to close a supply port.

A movable element 2 as described later is connected in the vicinity of center of a shaft portion of the supply valve 1. During the time when the engine is not operated, the movable element 2 is biased in the closing direction by a spring 13 to prevent the supply valve 1 from coming down.

Numeral 3 depicts a drive assembly. As in the drawing of the drive assembly 3, the upper end portion is provided with a fixed magnetic pole 31 of ring shape opposing to the lower center portion of the movable magnetic pole 11 and a fixed magnetic pole 32 of ring shape opposing to the lower face peripheral portion of the movable magnetic pole 11. The fixed magnetic poles 31 and 32 are concentrically disposed. An exciting coil 33 for exciting the magnetic poles 31 and 32 are arranged in a ring shape groove formed by the magnetic poles 31 and 32.

The fixed magnetic pole 31 is peripherally disposed with very small space apart from the outer circumference surface of the shaft portion of the supply valve 1. A center magnetic pole 34 is provided extending in the lower direction of the fixed magnetic pole 31.

The center magnetic pole 34 is formed in a cylindrical configuration and is arranged at a portion surrounding the shaft of the supply valve 1. The outer circumference of the center magnetic pole 34 is opposed to the inner circumference of the movable element 2.

In the drive assembly 3, there are provided two rows of stator magnetic poles 35 opposing each other at two positions through the outer circumference of the center magnetic pole 34 and the movable element 2, or opposing each other embracing the movable element 2. The stator magnetic poles 35 are provided in a plurality of stages in the reciprocating direction of the movable element 2. The stator magnetic poles 35 are wound with a primary coil 36 and flux density and flux direction respectively passing through the stator magnetic poles 35 are controlled at the respective stage basis. Figure 1 shows part of the flux flow generated from the stator magnetic poles 35 with an arrow mark.

Numeral 4 depicts a controller comprising an input / output interface taking charge of input / output of signals, ROM storing previously program or various related maps, CPU executing computation with reference to the program stored in said ROM, RAM temporarily storing computed result or data, a control memory controlling signal flow within the controller 4, and others.

An initial drive apparatus 41 and a speed adjustment apparatus 42 are connected to the controller 4. The initial drive apparatus 41 is connected to the exciting coil 33. When the control signal from the controller

33 is inputted to the exciting coil 33, the exciting coil 33 receives power and excites the fixed magnetic poles 31 and 32.

The speed adjustment apparatus 42 is connected in each stage basis to the primary coil 36. With the speed control signals being inputted from the controller 4, the speed adjustment apparatus 42 supplies AC power of different phases in every stage of the primary coil 36 to form a travelling magnetic field by the flux passing through the stator magnetic poles 35, the travelling magnetic field being controlled of its travelling speed and direction.

In figure 2, numeral 3' depicts another supply valve provided adjacent with the supply valve 1 or the drive assembly for driving the supply valve. The drive assembly 3 and the drive assembly 3' are juxtaposed so that respective lines including points where the fixed magnetic poles 35 are located may be in parallel as shown in the drawing. Thus, the installation pitch of the drive assemblies 3 and 3' may be reduced.

Numeral 5 depicts a barrier limiting a location in mounting the drive assembly 3. As in the drawing, the location the supply valve 1 may be neared to the barrier 5 by making the lines connecting the fixed magnetic poles 35 are parallel with the wall face of the barrier 5.

Next the movable element 2 is explained.

Figure 3 is a perspective sectional view of the movable element.

The movable element 2 is in a cup configuration or in the form of cylindrical shape with a bottom. The movable element 2 comprises: a core 21 made of composite material including magnetic substance powder and plastic; a plurality of secondary coils 22 with closing ring configurations held by the core 21.

The magnetic substance powder included in the core 21 is formed of, for example, short fibre of silicon steel or fine grain of the same. The magnetic substance powder being kneaded with the plastic before hardening of the plastic, and resultant mixed substance is filled in the mold arranged with the second coils 22 on specified positions, to form the movable element 2.

The movable element 2 may also be formed, alternatively, by means of heating the plastic to melt after filling into mold by mixing plastic powder of thermal plasticity with magnetic substance powder.

Due to the required light weight, the secondary coils 22 are formed of, for example, electrically conductive metallic material such as aluminium and the like having smaller specific gravity or otherwise of conductive ceramic.

The movable element 2 thus produced has excellent magnetic permeability with light weight, therefore inertia mass of reciprocating drive system of the supply valve 1 may be greatly reduced.

Next, the apparatus according to the invention using the construction described above is described

as follows.

During the time when the engine is operated, the controller 4 is always continuing to detect rotation phase of the engine and its load, a computation being made for the opening / closing timing and the lift amount of the supply valve corresponding to the engine load. When an actual rotational phase of the engine reaches the calculated opening / closing timing of the supply valve, the controller 4 outputs control signals to an initial drive apparatus 41. In this operation, the exciting coil 33 receives power to excite the fixed magnetic poles 31 and 32. Figure 4 illustrates a profile where the fixed magnetic pole 31 is excited to S polarity and the magnetic pole 32 to N polarity.

Figure 4 is an illustration of the flux exerting on a movable magnetic pole.

In the drawing, arrow mark B indicates flux travelling. As shown in the drawing, the fixed magnetic pole 32 emits the flux which travels through inside the movable magnetic pole 11 to form magnetic path continuing into the fixed magnetic pole 31. From this operation, the movable magnetic pole 11 is attracted to all the circumferences of the fixed magnetic poles 31 and 32, a very strong initial driving force may thus be produced even when the diameter of the movable magnetic pole 11 is smaller than the external diameter where the stator magnetic poles 35 are provided.

When the movable magnetic pole 11 has a constant thickness, magnetic flux density inside the movable magnetic pole 11 becomes smaller at the outer circumference thereof than the center portion. Accordingly, attracting force is not reduced even when the constant magnetic flux density between the central portion and the outer circumference portion is made constant by decreasing thickness of the outer circumference as in the drawing.

Further with such thinner thickness used, the reciprocating movement system of the supply valve 1 has a reduced inertia mass, so that a larger acceleration is thus realized.

When the exciting coil 33 receives electric power and initially drives the supply valve 1, the supply valve is driven up to the lift amount computed as hereinbefore described. The supply valve 1 is adjusted of its moving speed so as to sit the supply valve 1 on the valve seat 14 using the closing timing further calculated. An adjustment of moving speed is performed by outputting speed control, signals to the speed adjustment apparatus 42 from the controller 4 as described above.

The spring 14 holding the supply valve 1 at a closing state has a biasing force being set satisfactorily smaller against the electromagnetic force.

While the present invention has been explained in detail and described with reference to preferred embodiments thereof, since the invention is readily capable of other various embodiments without departing from the spirit of the invention, the present inven-

tion is not restricted to any particular embodiments other than the scope of the appended claims in the invention.

Claims

(1) An apparatus for driving valve by electromagnetic force, for driving a supply / exhaust valve by an electromagnetic force acting between a primary coil and secondary coils, the primary coil being fixed on an engine and generating magnetic flux, the secondary coils capable of reciprocating movement inducing current by said flux and being connected to the supply / exhaust valve, comprising:

a fixed magnetic pole which is wound with the primary coils and which is opposingly disposed embracing the secondary coils in the perpendicular direction to the reciprocating direction of the secondary coils;

an air gap adjacent with a tip end of the fixed magnetic pole and provided in the middle of a magnetic flux path generated from the primary coil;

a movable element adapted to be made of magnetic substance, to move capable of reciprocating in the air gap, to form part of the magnetic flux path, and to contain the secondary coils.

(2) An apparatus for driving valve by electromagnetic force as claimed in claim 1, wherein the opposing directions respectively of the fixed magnetic pole for driving the supply valve and the fixed magnetic pole for driving the exhaust valve are in parallel with each other.

(3) An apparatus for driving an electromagnetic force valve as claimed in claim 1, wherein a plurality of the secondary coils are provided aligned in the reciprocating movement direction thereof.

(4) An apparatus for driving valve by electromagnetic force as claimed in claim 1, wherein the supply / exhaust valve is made of ceramic as high strength and light weight material.

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Fig. 1

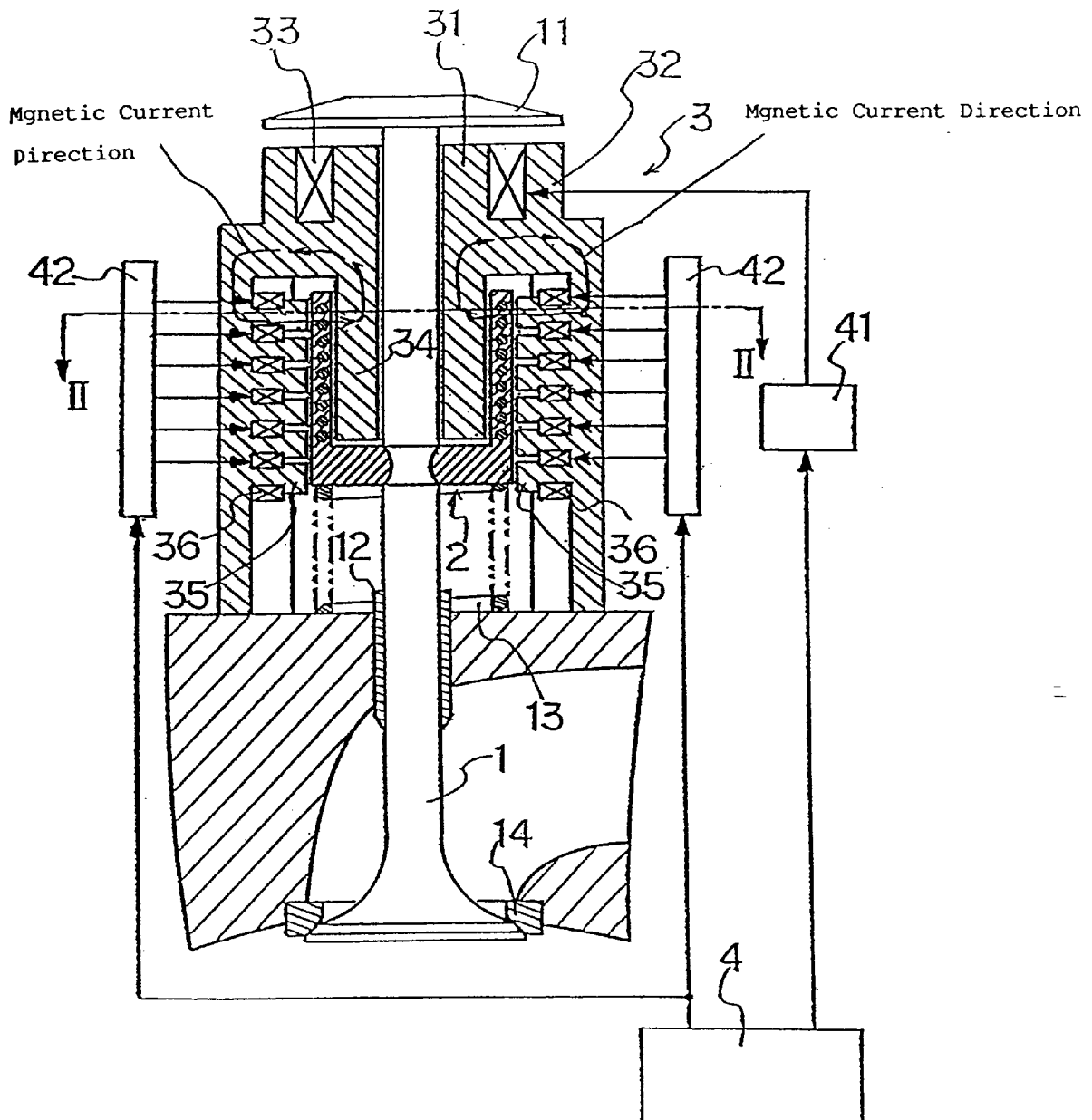


Fig. 2

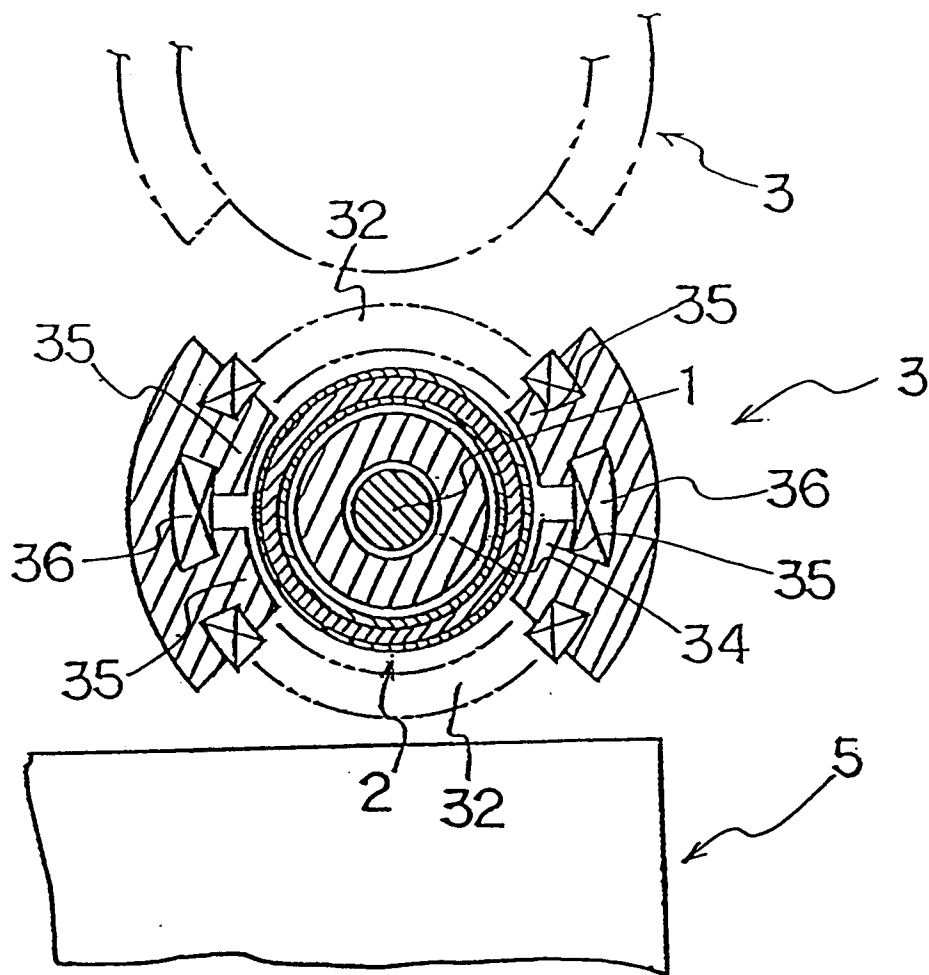


Fig. 3

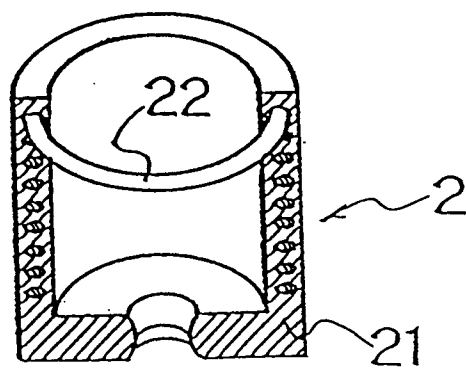
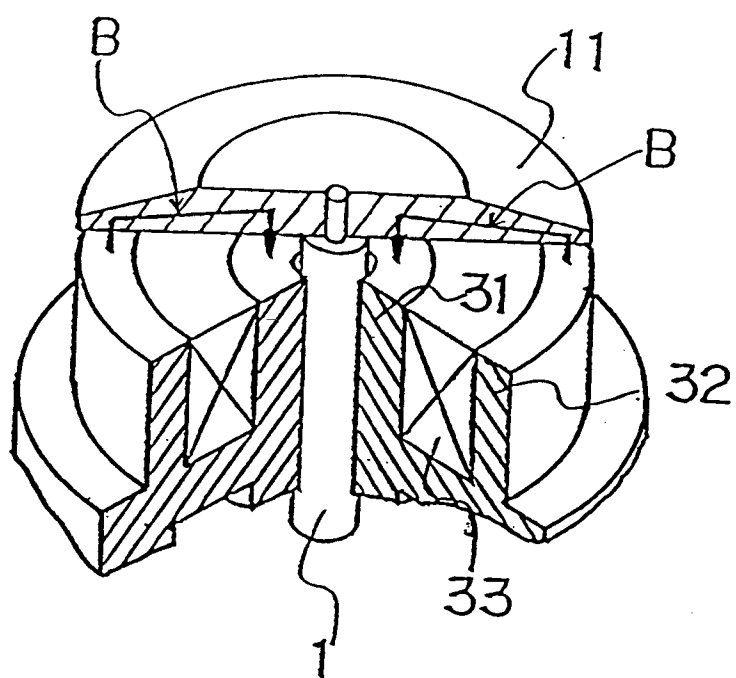


Fig. 4





European Patent
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EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0353

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X,P	PATENT ABSTRACTS OF JAPAN vol. 15, no. 272 (M-113)10 July 1991 & JP-A-3 092 520 (ISUZU CERAMICS KENKYUSHO KK) 17 April 1991 * abstract *	1,3	F01L9/04
X,P	PATENT ABSTRACTS OF JAPAN vol. 15, no. 272 (M-113)10 July 1991 & JP-A-3 092 517 (ISUZU CERAMICS KENKYUSHO KK) 17 April 1991 * abstract *	1,3	
X,P	PATENT ABSTRACTS OF JAPAN vol. 15, no. 272 (M-113)10 July 1991 & JP-A-3 092 518 (ISUZU CERAMICS KENKYUSHO KK) 17 April 1991 * abstract *	1,3	
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 436 (M-102)18 September 1990 & JP-A-2 173 306 (ISUZU MOTORS LTD) 4 July 1990 * abstract *	4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F01L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 17 FEBRUARY 1992	Examiner ALCONCHEL Y UNGRIA J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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